PLANAR MEMBRANE DEOXYGENATOR

BACKGROUND OF THE INVENTION

This invention relates generally to a method and device for removing dissolved oxygen from fuels and specifically to a planar membrane for removing dissolved oxygen from liquid hydrocarbon fuels.

It is common practice to use fuel as a cooling medium for various systems onboard an aircraft. The usable cooling capacity of a particular fuel is limited by coke deposition, which is dependent on the amount of dissolved oxygen present within the fuel due to prior exposure to air. Reduction of the amount of dissolved oxygen within the fuel can result in the reduction of coke formed within the fuel delivery and injection system of the aircraft engine. Increasing the temperature of fuel also increases the rate of the oxidative reaction that occurs. It has been determined that decreasing the amount of dissolved oxygen present within the jet fuel reduces the formation of insoluble products referred to as "coke" or "coking". FIG. **1** illustrates the amount of coke formation for various grades of aircraft fuels. As appreciated from a study of the graph, deoxygenation suppresses coke formation across various aircraft fuel grades. Reducing the amount of oxygen dissolved within the jet fuel decreases the rate of coke deposition and increases the maximum allowable temperature. In other words, the less dissolved oxygen within the fuel, the higher the temperature before coke buildup becomes a problem. For many fuels, in order to suppress coke deposition, it is generally agreed that the concentration of dissolved oxygen should be reduced below approximately 2 ppm or approximately three percent of saturation. Aircraft fuels that currently have improved coking performance are generally more expensive or require additives, and therefore are not always available.

U.S. Pat. No. 6,315,815, assigned to Assignee of the current application, discloses a device for removing dissolved oxygen using a tubular gas-permeable membrane disposed within the fuel system. Fuel flows through tubes having an inner surface comprising a permeable membrane. As fuel passes along the permeable membrane, oxygen molecules in the fuel dissolve into the membrane and then diffuse across it and are removed A vacuum or oxygen partial pressure differential across the permeable membrane drives oxygen from the fuel, which is unaffected and passes over the membrane.

As is appreciated tubular membranes are difficult to manufacture and are limited in size and construction by tubing sizes and economic factors. Tubular membrane bundles arc difficult to scale because performance is highly dependent on spacing and geometry and thus hard to predict. High pressures are also a concern with tubular membranes. Further, space and weight are driving factors for any system installed on an airframe, and any reduction in space and weight provide immediate benefits to the operation of the aircraft.

Accordingly it is desirable to design a permeable membrane system that can remove dissolved oxygen from fuel down to the level required to suppress coke formation, and to configure it such that it efficiently utilizes space, reduces weight, is easily scalable, performs predictably, and can be manufactured economically.

SUMMARY OF THE INVENTION

This invention is a fuel deoxygenator assembly including a fuel plate that defines fuel flow passages between a fuel inlet and outlet. The fuel plate is sandwiched between permeable membranes backed by a porous plate. An oxygen concentration gradient partial pressure differential created between fuel within the fuel flow passages and the porous plate provides the driving force or chemical potential to draw dissolved oxygen from fuel through the permeable membrane to reduce the dissolved oxygen content of the fuel. The oxygen concentration gradient is manifested by the partial pressure differential of the oxygen and drives the oxygen through the membrane.

The fuel deoxygenator assembly includes a plurality of fuel plates sandwiched between permeable membranes and porous backing plates disposed within a housing. Each fuel plate defines a portion of the fuel passage and the porous plate backed permeable membranes define the remaining portions of the fuel passages. The permeable membrane includes Teflon or other type of amorphous glassy polymer coating in contact with fuel within the fuel passages for preventing the bulk of liquid fuel from migrating through the permeable membrane and the porous plate. Trace amounts of fuel, nitrogen, and other gases may also migrate through the membrane without any deleterious effects.

The use of a plurality of similarly configured flat plates increases manufacturing efficiency and reduces overall cost. Further, the size and weight of the deoxygenator assembly is substantially reduced over prior art systems while increasing the capacity for removing dissolved oxygen from fuel. Moreover, the planar design is easily scalable compared to previous tubular designs.

Accordingly, the fuel deoxygenator assembly of this invention increases and improves the amount of dissolved oxygen that may be removed from fuel while also reducing the amount of space and weight required for accomplishing fuel deoxygenation.

BRIEF DESCRIPTION OF THE DRAWINGS

The various features and advantages of this invention will become apparent to those skilled in the art from the following detailed description of the currently preferred embodiment. The drawings that accompany the detailed description can be briefly described as follows:

FIG. **1** is a graph illustrating examples of Deoxygenation suppressing coke formation.

FIG. **2** is a schematic view of a fuel deoxygenation system;

FIG. **3** is a schematic view of another fuel deoxygenation system;

FIG. **4** is a cross sectional view of the fuel deoxygenator assembly;

FIG. **5** is a cross sectional view of plates through the fuel inlet;

FIG. **6** is a cross sectional view of plates through the vacuum opening;

FIG. **7**, is a cross-sectional view of fuel passages;

FIG. **8** is an exploded view of plates comprising fuel flow passages within the fuel deoxygenator assembly;

FIG. **9** is a perspective view of a fuel plate;

FIG. **10** is a schematic view of fuel passages defined by the fuel plate; and

FIG. **11** is another embodiment of fuel passages defined by the fuel plate.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to FIG. **2**, a fuel deoxygenator system **10** includes deoxygenator assembly **12** for removing dissolved